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ON THE SUGGESTED MUTUAL REPULSION OF FRAUNHOFER LINES

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The correct interpretation of the results given by the spectroscope is so fundamental to progress in present day astronomy that every suggestion offering new points of view and avenues of approach to the problems furnished by the powerful instruments in commission deserves consideration. The spectrographs now used upon the sun yield spectra of such a scale and dispersion that minute changes in spectrum lines can be studied that were beyond the reach of the older instruments.

Changes in the relative position of spectrum lines are the phenomena most often under consideration. All astrophysicists recognize two conditions that produce displacements of the Fraunhofer lines, motion in the line of sight and differences in pressure, both capable of precise determination. Two others have been suggested, the gravitational effect of Einstein[1] and the anomalous dispersion hypothesis of Julius.[2] The former influence would displace all lines to a calculable amount and would, if found, add no serious difficulties to the solar problem. The effects of anomalous dispersion, however, would introduce an indeterminate factor into the spectroscopic problem. It becomes then a matter of prime importance to determine whether the relative positions of the Fraunhofer lines are measurably affected by this cause.

An accepted deduction from the theory is a mutual influence between neighboring lines, a quasi repulsion increasing with the proximity of the adjacent lines. The violet and red components of a close pair must then be displaced to the violet and red, respectively, in comparison with the displacement of the isolated lines of the same class. Displacements between the solar and arc lines give a direct and definite means of testing the question.

Iron, from its abundance of lines and the searching investigations given to them, furnishes the most reliable data. The wave lengths of the iron lines belonging to groups *a*, *b* and *c4* of the Mount Wilson classification are independent of arc conditions.[3] These lines therefore are capable of giving results of the highest possible precision. The mean sun-arc displacement for 213 lines of these groups is +0.0039 A. Those who assign an important rôle to anomalous dispersion in the solar atmosphere assume that solar lines within 0.5 A from each other are subject to mutual repulsion. The mean displacement for 30 lines with companions at an average distance of 0.314 A to the red is +0.0042A; for 59 lines with companions at an average distance of 0.270 A to the violet it is +0.0040 A. The displacements for the three cases are equal within the limits of accidental error, and, within such limits, the equality shows the absence of mutual influence.

Since a detectable mutual repulsion between adjacent solar lines should increase their separation over that determined from terrestrial sources, another approach to the question is found through such a comparison. It is usually assumed that repulsion occurs between all closely adjacent solar lines. For 45 pairs, mean separation 0.29 A, the differences Δλ Sun – Δλ Arc are positive for 17, negative for 21 and zero for 7 lines, the mean differences being zero. It has recently been suggested[4] that repulsion is to be expected only if the line in the solar spectrum has a closely adjacent line due to another substance not present in the arc. The following data from recent determinations do not show the differences required by the theory, though the lines are due to different elements and originate in separate arcs.

λ *Rowland*		Δλ *Sun*	Δλ *Arc*	Δλ *Sun* – Δλ *Arc*
4058.915	Fe			
.081	Mn	.170	.173	–0.003
4226.904	Ca			
.606	Fe	.700	.710	–0.010
4315.138	Ti			
.262	Fe	.115	.115	0.000
4427.266	Ti			
.482	Fe	.215	.213	+0.002
4454.552	Fe			
.953	Ca	.399	.399	0.000
4489.911	Fe			
.253	Mn	.340	.340	0.000
5208.596	Cr			
.776	Fe	.169	.170	–0.001
5446.797	Ti			
.130	Fe	.332	.334	–0.002
Mean........		.305	.307	–0.0018

Recently Albrecht[5] found by comparing the Rowland and International wave-lengths of iron lines that the violet and red components of a solar pair showed apparent displacements to the violet and red of 0.007 and 0.005A, respectively. He interpreted these as effects of anomalous dispersion, an interpretation accepted by Julius, who says,[6] "Only if the Fraunhofer lines are *mainly* due to anomalous dispersion will they be able to show a mutual influence of the observed kind and magnitude." The absence of mutual influence would, within the limits of error, remove any direct evidence that anomalous dispersion contributes to the production of the Fraunhofer lines.

As the Mount Wilson data for sun-arc displacements and for the comparative separation between close pairs of lines in solar and terrestrial spectra do not show the effect of mutual influence, it seems necessary to assume either that the Mount Wilson data are affected by systematic errors just sufficient to annihilate the effect of anomalous dispersion, or that the Rowland wave-lengths for lines in close pairs are systematically in error; a slight over-separation of such pairs would introduce an effect of the sign indicated by the theory. The results of an investigation upon "The Accuracy of the Measured Separations of Close Solar Pairs; Systematic Errors in the Rowland Table for such Lines" are given in a Contribution from this Observatory.[7] For pairs consisting of lines of intensities 3 and 4, with mean separations of 0.274, 0.145 and 0.075 A, the Rowland separations exceed the Mount Wilson values by 0.003, 0.008 and 0.013 A, respectively. As errors of this sign and magnitude would account for the deviations found by Albrecht, an exhaustive examination of the cases included in Albrecht's list was undertaken; details of this investigation will appear in a Contribution from this Observatory.

The wave-lengths of the 104 lines used by Albrecht have been referred to those of neighboring free-standing lines. The measurements have been made by two observers upon spectrograms of a scale and dispersion that previous experience had shown were best adapted to each case. The errors found in the Rowland values are systematic and of a sign and magnitude corresponding to the Albrecht deviations. This correspondence is marked, large and small values of the one being associated with large and small values of the other. The coefficient of correlation between the two sets of observations is $+0.55 \pm 0.05$, indicating that the correlation is a practical certainty. No explanation of this correlation seems possible other than that the errors in the Rowland wave-lengths and the Albrecht deviations are two phases of the same phenomenon, that in fact the deivations observed by Albrecht are a measurement of the Rowland errors.

Summary and Conclusion.—1. The violet and red components of close pairs of solar lines show the same displacement as isolated lines when compared with the spectrum of the arc.

2. The mean separation of close pairs in the solar spectrum is the same as that determined from terrestrial sources whether the component lines are due to the same or different elements.

3. The Rowland wave-lengths for close pairs of solar lines are sys-

tematically in error; the violet and red components being assigned values, respectively too small and too large.

4. The systematic deviations for lines with violet and red companions found by comparing the Rowland and International wave-lengths go pari passu with and are referable to the erros in Rowland wave-lengths. The coefficient of correlation is +0.55 ± 0.05.

5. These systematic deviations, therefore, do not furnish evidence that the relative positions of the Fraunhofer lines are systematically displaced by mutual influence. On the other hand, the sun-arc displacements and the relative separation of the components of close pairs in solar and arc spectra indicate that, within the limits of error, evidence of mutual influence is absent from the solar spectrum, and, in so far as mutual influence is a necessary corollary of anomalous dispersion in the sun, evidence for it also is absent.

[1] A. Einstein, *Leipzig, Ann. Phys*, 35, 898 (1911).

[2] W. H. Julius, *Astrophys. J.*, 40, 1 (1914).

[3] *Trans. Internat. Union Co-op. Solar Res.*, 4, 74. Charles E. St. John and Harold D. Babcock, 'A Study of the Pole Effect in the Iron Arc,' *Mt. Wilson Contr.*, 106; *Astrophys. J.*, 46, (1915).

[4] Sir Joseph Larmor, *Observatory*, 497, 103 (1916).

[5] Sebastian Albrecht, *Astrophys. J.*, **41**, 333 (1915).

[6] W. H. Julius, *Astrophys. J.*, 43, 53 (1916).

[7] Charles E. St. John and L. W. Ware, *Mt. Wilson Contr.*, —, *Astrophys. J.*, — (1916).

AN ATTEMPT TO DETECT THE MUTUAL INFLUENCE OF NEIGHBORING LINES IN ELECTRIC FURNACE SPECTRA SHOWING ANOMALOUS DISPERSION

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When light traverses a transparent medium, the variation of the index of refraction with the wave-length of the incident light may undergo decided changes if the medium shows selective absorption. If a beam of white light is passed through a mass of vapor which is itself emitting a spectrum, the sudden change of refractive index close to the absorption lines can be shown by suitable optical arrangements. One method of producing this effect is based on the principle of crossed prisms used by Kundt, and consists in making the absorbing medium form a prism whose refracting edge is at right angles to the slit of the analysing spectroscope. An absorption line showing anomalous dispersion will then cause the continuous spectrum to bend sharply in opposite directions